### Project Title:
Trans Adriatic Pipeline – TAP

### Document Title:
Project Basic Design - Italy

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<td>Ricci Luigi</td>
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<th>Description</th>
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<tr>
<td>ACS</td>
<td>Access Control System</td>
</tr>
<tr>
<td>AHT</td>
<td>Anchor Handling Tug</td>
</tr>
<tr>
<td>AON</td>
<td>Active Optical Network</td>
</tr>
<tr>
<td>AVAS</td>
<td>Audio Visual Alerting System</td>
</tr>
<tr>
<td>BHD</td>
<td>Back-hoe Dredger</td>
</tr>
<tr>
<td>Bcm</td>
<td>Billion Cubic Meters</td>
</tr>
<tr>
<td>BVS</td>
<td>Block Valve Station</td>
</tr>
<tr>
<td>CC</td>
<td>Concrete Coating</td>
</tr>
<tr>
<td>CCR</td>
<td>Central Control Room</td>
</tr>
<tr>
<td>CCT</td>
<td>Concrete Coating Thickness</td>
</tr>
<tr>
<td>CCTV</td>
<td>Closed Circuit TeleVision System</td>
</tr>
<tr>
<td>CPI</td>
<td>Fire Prevention Certificate (Certificato Prevenzione Incendi)</td>
</tr>
<tr>
<td>DCVG</td>
<td>Direct Current Voltage Gradient</td>
</tr>
<tr>
<td>DM</td>
<td>Ministerial Decree</td>
</tr>
<tr>
<td>DN</td>
<td>Nominal Diameter</td>
</tr>
<tr>
<td>DP</td>
<td>Design Pressure</td>
</tr>
<tr>
<td>DPR</td>
<td>Decree of Republic President</td>
</tr>
<tr>
<td>ESD</td>
<td>Emergency Shutdown</td>
</tr>
<tr>
<td>EEZ</td>
<td>Exclusive Economic Zone</td>
</tr>
<tr>
<td>FDS</td>
<td>Fire Detection System</td>
</tr>
<tr>
<td>GDS</td>
<td>Gas Detection System</td>
</tr>
<tr>
<td>HIPPS</td>
<td>High Integrity Pressure Protection System</td>
</tr>
<tr>
<td>ID</td>
<td>Internal Diameter</td>
</tr>
<tr>
<td>KP</td>
<td>Kilometre Point onshore section</td>
</tr>
<tr>
<td>KPof</td>
<td>Kilometre Point offshore section</td>
</tr>
<tr>
<td>LDS</td>
<td>Leak Detection System</td>
</tr>
<tr>
<td>LR</td>
<td>Regional Law (Legge Regionale)</td>
</tr>
<tr>
<td>MOP</td>
<td>Maximum Operative Pressure</td>
</tr>
<tr>
<td>MTBM</td>
<td>Microtunnel Boring Machine</td>
</tr>
<tr>
<td>NDT</td>
<td>Non-destructive Test</td>
</tr>
<tr>
<td>OD</td>
<td>External Diameter</td>
</tr>
<tr>
<td>PON</td>
<td>Passive Optical Network</td>
</tr>
</tbody>
</table>
**Abbreviation** | **Description**
--- | ---
OLB | Offshore Lay-barge
PRT | Pipeline Receiving Terminal
PSA | Piping Stress Analysis
ROW | Right of Way
SCADA | Supervisory Control and data Acquisition System
SG | Specific Gravity
SP | Provincial Road (Strada Provinciale)
SRG | Snam Rete Gas
SS | National Road (Strada Statale)
TAP | Trans Adriatic Pipeline
TBM | Tunnel Boring Machine
UXO | Unexploded Ordnance
VIV | Vortex Induced Vibration
WD | Water Depth
WF | Weight Factor
WT | Wall Thickness
1 INTRODUCTION

Trans Adriatic Pipeline will transport gas via Greece and Albania and across the Adriatic Sea to Italy’s southern Puglia Region and further to Western Europe. Crossing the Adriatic Sea from central-western Albania, the offshore pipeline gets onshore in south-east Italy and ties in to the Italian gas network South of Lecce.

Across the Adriatic Sea the gas will be transported via a 36" pipeline to an onshore receiving terminal (TAP Receiving Terminal) that will be connected to the existing Snam Rete Gas network. The project is aimed at enhancing security of supply as well as diversification of gas supplies for the European markets. TAP has also incorporated provisions to accommodate physical reverse flow. The total pipeline length is 871 km approximately.

The pipeline system in Italy would consist of an approximately 45 km long offshore pipeline, from the Italian jurisdiction boundary (middle of the Adriatic Sea) to the Italian coast (KPof 60.144 – KPof 104.975, considering KPof 0 the Albanian Landfall), an approximately 8.2 km long onshore pipeline (KP 0 – KP 8.203), considering KP 0 the entry point of the offshore microtunnel, and a Pipeline Receiving Terminal (also referred to as PRT) near Melendugno in the province of Lecce with an initial nominal capacity of 10 BCM (expandable to 20 BCM) of natural gas per year (around 1.190.000 standard cubic metres per hour).

The intersection point between the offshore and onshore pipeline is the entry point of the offshore microtunnel foreseen for the landfall; this point is defined as KPof 104.975 (end of the offshore section) and KP 0 (start point of the onshore section).

The pipeline landfall will be on the coast between San Foca and Torre Specchia Ruggeri in the municipality of Melendugno. The landfall will be constructed using micro-tunnelling technology to minimize the visual and environmental impact on the coastline. Figure 1-1 shows the TAP – General Overview.
The project will also include a Fiber Optic Cable (FOC) to enable communication between the TAP Receiving terminal where the supervisory control centre is located, the compressor stations in Albania and Greece as well as the block valve stations installed along the 871 km long pipeline.

The FOC shall be laid parallel to the pipeline, along the entire route (onshore and offshore) and will be the primary means of communication between the pipeline stations.
2 DESIGN DATA

2.1 Offshore Section (Adriatic Sea to Landfall Microtunnel entry point)

The offshore pipeline is described by the following basic data, which are in compliance with Italian DM 17/04/2008 and DNV OS F101:

- Type of gas pipeline: Type 1
- Design pressure (DP): 145 bar
- CPI (Fire Prev. Cert.) Pressure (MOP): 145 bar
- Gas transported: Natural Gas
- Nominal diameter: DN 900 (36")
- Internal diameter: 871 mm (constant)
- Material: Steel – Grade L450
- Wall Thickness (to comply with DnV OS F101 and DM 17/04/2008):
  - Offshore as far as microtunnel end: between 20.6 and 34 mm
  - Microtunnel: 34 mm

2.1.1 Landfall Tunnel Design

Provisional main characteristics of the required Microtunnel are:

- OD: 3000 mm
- Length: 1485 m

The estimated volume of soil to be excavated for the Microtunnel construction is about 10500 m$^3$. Provisional dimensions of the launch shaft are:

- Depth: 11 m
- Length: 10 m
- Width: 12 m

The estimated volume of soil to be excavated for the launch shaft construction is about 1300 m$^3$. The envisaged suitable location for the Microtunnel exit point is around at -18.0 m WD, and 867 m far from the shore line.

Figure 2-1 shows a plan view of the area of the landfall tunnel.
2.1.2 Pipeline Stability

Calculations have been performed applying the criteria given in DNV-RP-F109 “On Bottom Stability Design of Submarine Pipelines”, both in temporary and long term conditions. A concrete coating with density of 3050 Kg/m³ is considered. The pipeline stability assessment has been carried out assuming, for the concrete, a water absorption of 2% by weight. Stability calculations have been performed for the entire pipeline section resting on the natural seabed, i.e. out of Microtunnel.

Table 2-1 shows the minimum concrete thicknesses for the lateral pipeline stability.
### Lateral Stability Checks

<table>
<thead>
<tr>
<th>Section</th>
<th>From KPoF</th>
<th>To KPoF</th>
<th>Length</th>
<th>From WD1</th>
<th>To WD2</th>
<th>WT</th>
<th>@ WD1</th>
<th>@ WD2</th>
<th>@ WD1</th>
<th>@ WD2</th>
<th>Selected CCT</th>
</tr>
</thead>
<tbody>
<tr>
<td>19-23</td>
<td>60.100</td>
<td>79.400</td>
<td>19300</td>
<td>-806</td>
<td>-125</td>
<td>34</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>24-26</td>
<td>79.400</td>
<td>97.800</td>
<td>18400</td>
<td>-125</td>
<td>-99</td>
<td>20.6</td>
<td>50.4</td>
<td>50.4</td>
<td>50.4</td>
<td>50.4</td>
<td>55</td>
</tr>
<tr>
<td>27-29</td>
<td>97.800</td>
<td>102.713</td>
<td>4913</td>
<td>-99</td>
<td>-44</td>
<td>23.8</td>
<td>50.4</td>
<td>50.4</td>
<td>50.4</td>
<td>50.4</td>
<td>55</td>
</tr>
<tr>
<td>30-31</td>
<td>102.713</td>
<td>103.490</td>
<td>777</td>
<td>-44</td>
<td>-20</td>
<td>23.8</td>
<td>81.7</td>
<td>79.8</td>
<td>110.3</td>
<td>105.6</td>
<td>120</td>
</tr>
<tr>
<td>32-34</td>
<td>102.490</td>
<td>104.975</td>
<td>1485</td>
<td>-20</td>
<td>0</td>
<td>34</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Table 2-1 – Lateral Stability Checks

Table 2-2 shows, for the selected concrete coating thickness the relevant submerged weight and specific gravity

### Vertical Stability Check- Empty Condition

<table>
<thead>
<tr>
<th>Pipe type</th>
<th>Nominal Steel Thickness (mm)</th>
<th>Concrete Coating Thickness (mm)</th>
<th>Pipeline Submerged Weight (Empty) (kN/m)</th>
<th>Pipeline Specific Gravity (Empty)</th>
<th>Pipeline Weight in Air (kN/m)</th>
<th>Total External Diameter (1) (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WT=34 mm CT=0mm</td>
<td>34</td>
<td>0</td>
<td>0.487</td>
<td>1.06</td>
<td>8.464</td>
<td>0.945</td>
</tr>
<tr>
<td>WT=20.6 mm CT=55mm</td>
<td>20.6</td>
<td>55</td>
<td>1.112</td>
<td>1.13</td>
<td>9.467</td>
<td>1.028</td>
</tr>
<tr>
<td>WT=23.8 mm CT=55mm</td>
<td>23.8</td>
<td>55</td>
<td>1.750</td>
<td>1.21</td>
<td>10.228</td>
<td>1.035</td>
</tr>
<tr>
<td>WT=23.8 mm CT=120mm</td>
<td>23.8</td>
<td>120</td>
<td>6.325</td>
<td>1.63</td>
<td>17.020</td>
<td>1.165</td>
</tr>
</tbody>
</table>

Note (1) – Corrosion coating 3mm included

Table 2-2 – Vertical Stability Check- Empty Condition

Based on the above, the following considerations are worthy of notes:

- For the WT 23.8mm, the 120mm and 55mm, required for the lateral stability, fulfil the SG requirement.
- For the WT 20.6mm, the 55mm, required for the lateral stability, fulfils the SG requirement.
- The SG of the WT 34mm, uncoated, is below 1.1. In this case the DNV-RP-F109 requires just to ascertain that the event of pipe floatation in water is unlikely. In general, floatation (null submerged weight) might occur as a consequence of combinations of dimensional variations, in particular wall thickness and diameter. Calculations have shown that, even considering the worst combination of such parameters, within the allowed tolerances, the minimum submerged weight of 0.252 kN/m can be ensured that is enough to avoid floatation.

The selected wall thickness and concrete distribution in the Italian EEZ is shown in Table 2-3:
### 2.1.3 Intervention works along the offshore pipeline

Intervention works are necessary along the offshore pipeline route to comply with the applicable rules i.e. with DnV OS F101, DnV RP F105, DnV RP F109 and DM 17/04/2008.

In particular interventions with gravel dumping and/or post trenching excavations may be necessary for:

- **Preventing the failure for Local Buckling limit state, DnV OS F101.**
- **Preventing excessive fatigue damage, DnV RP F105.** It is applicable to fatigue due to waves induced VIV in installation and empty condition.
- **Mitigating the bottom roughness and free span reduction.**

Interventions with gravel dumping and/or concrete mattresses may be necessary to:

- Guarantee the minimum separation of 30cm between pipe and cable in correspondence of the crossings.
- Post trenching excavations may be necessary for:
  - Burying the pipe to ensure on-bottom stability “in alternative with/in addition to” concrete overweighing.

The amount and the locations of such interventions are not yet defined.

### 2.1.4 Intervention works at the Landfall

#### 2.1.4.1 Excavations

An excavation shall be carried out at Microtunnel exit, on the seabed, at a distance of 867m from the shore line (approx. water depth range = 18 ÷ 27 m) due to the following reasons:
• Recovery the TBM in the proximity of the tunnel exit seawards (KPof 103.090)
• Prepare the seabed for the pull-in of the pipe.

Table 2-4 summarizes the basis of the calculations and the estimated excavation and backfilling volume. The possible maintenance dredging volume is not included.

<table>
<thead>
<tr>
<th>Distance from shore line</th>
<th>Length</th>
<th>WD Range</th>
<th>Base Width</th>
<th>Slope</th>
<th>Max Trench Depth</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>From (m)</td>
<td>To (m)</td>
<td>(m)</td>
<td>(m)</td>
<td>(m)</td>
<td>(m)</td>
<td>Trench</td>
</tr>
<tr>
<td>867</td>
<td>977</td>
<td>110</td>
<td>-18/-27</td>
<td>4.0</td>
<td>1:4</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 2-4 – Excavation Works – Net Quantities

2.1.4.2 Gravel Dumping

An embankment with gravel dumping shall be erected out of the excavated trench from a distance of 977m to 1223m from the shore line. The scope is to facilitate the operation of pulling-in the pipeline through the Microtunnel.

Table 2-5 summarizes the characteristics and the volume of the embankment.

<table>
<thead>
<tr>
<th>Distance from shore line</th>
<th>Length</th>
<th>WD Range</th>
<th>Top Width</th>
<th>Slope</th>
<th>Max Height</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>From (m)</td>
<td>To (m)</td>
<td>(m)</td>
<td>(m)</td>
<td>(m)</td>
<td>(m)</td>
<td>(m³)</td>
</tr>
<tr>
<td>977</td>
<td>1223</td>
<td>246</td>
<td>-27/-32</td>
<td>10</td>
<td>1:3</td>
<td>2.7</td>
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</tbody>
</table>

Table 2-5 – Embankment Gravel Dumping – Net Quantities

2.1.5 Corrosion Protection

The whole pipeline is coated with 3LPE as per Table 2-6.

<table>
<thead>
<tr>
<th>Pipe Diameter</th>
<th>Internal Diameter (mm)</th>
<th>Nominal Length (m)</th>
<th>Wall Thickness (mm)</th>
<th>Pipe Coating Type and Thickness</th>
<th>Field Joint Coating Type and Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>36” (constant)</td>
<td>871</td>
<td>12.2</td>
<td>20.6 / 23.8 / 34.0</td>
<td>3LPE - 3.0 mm</td>
<td>HSS - 3.0 mm</td>
</tr>
</tbody>
</table>

Table 2-6 – Corrosion coating characteristics
Sacrificial anodes will be installed along the offshore pipeline. Table 2-7 and Table 2-8 give the anodes distribution and characteristics for the pipeline section inside the Italian EEZ.

<table>
<thead>
<tr>
<th>From KP&lt;sub&gt;off&lt;/sub&gt;</th>
<th>To KP&lt;sub&gt;off&lt;/sub&gt;</th>
<th>Concrete Coating thickness (mm)</th>
<th>Pipeline Condition</th>
<th>Anode Tag</th>
<th>Anode Spacing (joints)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60.100</td>
<td>79.400</td>
<td>-</td>
<td>Exposed</td>
<td>AN36A</td>
<td>9</td>
</tr>
<tr>
<td>79.400</td>
<td>102.787</td>
<td>55</td>
<td>Exposed</td>
<td>AN36B</td>
<td>10</td>
</tr>
<tr>
<td>102.787</td>
<td>103.387</td>
<td>120</td>
<td>Exposed</td>
<td>AN36D</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 2-7 – Anodes distribution

<table>
<thead>
<tr>
<th>Anode Tag</th>
<th>AN36A tapered</th>
<th>AN36B</th>
<th>AN36C</th>
<th>AN36D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outer diameter</td>
<td>1.045 m</td>
<td>1.025 m</td>
<td>1.058 m</td>
<td>1.155 m</td>
</tr>
<tr>
<td>Anode thickness</td>
<td>50 mm</td>
<td>50 mm</td>
<td>70 mm</td>
<td>115 mm</td>
</tr>
<tr>
<td>Anode length</td>
<td>0.781 m</td>
<td>0.500 m</td>
<td>0.500 m</td>
<td>0.500 m</td>
</tr>
<tr>
<td>Anode net weight</td>
<td>250.5 kg</td>
<td>165.1 kg</td>
<td>238.5 kg</td>
<td>419.0 kg</td>
</tr>
</tbody>
</table>

Table 2-8 – Anodes Characteristics

2.1.6 FOC installation and Burial

The Fiber Optic Cable (FOC) is laid along a route parallel to the pipeline at a distance of 50m approx. The installation will be performed with a dedicated vessel and the burial could be performed by another. The FOC, where necessary, will be buried 1m beneath the seabed to protect against trawl fishing, ships anchoring and other activities.
Note: The progressive 0.00 (Microtunnel Entry) corresponds to KPof 104.975m of the gas offshore pipeline. The progressive 1.485 (Microtunnel Exit) corresponds to KPof 103.490m of the gas offshore pipeline.

Figure 2-2 – Nearshore/Landfall Section – Pipeline and seabed profiles
2.2 Onshore Section (From Landfall Microtunnel entry point to PRT)

2.2.1 Design data

The basic data assumed for the feasibility of the route are shown below in compliance with DM 17/04/2008.

- Type of gas pipeline: Type 1
- Design pressure (DP): 145 bar
- CPI (Fire Prev. Cert.) Pressure (MOP): 145 bar
- Utilization factor (f) adopted: 0.57
- Gas transported: Natural Gas
- Nominal pipeline diameter: DN 900 (36”)
- Internal diameter: 871 mm
- Service easement area: 20 + 20 m
- Material: Steel – Grade X65/450
- Wall Thickness: 26.8 mm
- Pipeline Length: 8.2 km

2.2.2 Block valve station

One BVS will be installed close to the pipeline landfall at KP 0.1 in order to enable the isolation of the offshore pipeline from the onshore part for maintenance and safety purposes.

The block valve station is unmanned and contains as above ground features only a small cabinet for power and control system and a fence to avoid any interference, covering a total surface area of approximately 13 x 14 m (plus surrounding vegetation). The following figure illustrates the foreseen BVS layout plan.
The BVS will be remotely operated from a control centre in the PRT through a fibre-optic cable communication system and will be connected to the local power grid. The pipeline the block valve and by-pass valves as well as the connected piping will be buried below ground. Valve integrity is also monitored by the pipeline Leak Detection System.

In coherence with the selection of the onshore line pipes, the selection of the tubes constituting the block valve station is based on the same design standards and design specifications. The diameter of these tubes will be 12” for the by-pass line and 2” for branches to measuring instruments.

A permanent access road is foreseen, as shown in the Figure 2-4. Part of this access road will be a new one (yellow line) part will be an enlargement of the existing road (green line).
2.2.3 Depth of burial of the pipeline

With regard to the construction methods of gas pipelines in Italy, Ministerial Decree 17/04/2008 prescribes a minimum pipeline cover not less than 0.9 m and 0.4 in rocky soil from the top of the pipe. In any case gas pipelines in Italy are usually laid with a minimum cover of 1.5 m, in order to provide the maximum guarantees of safety from possible interference with human activities (excavating, ground-breaking for agricultural purposes etc.). The typical trench dimensions respecting the legal requirements can be seen in following figure.
2.2.4 Safety distances with respect to buildings

In accordance with Italian regulations no clusters of houses should be identified within a range of 100 m to the pipeline. In proximity to the planned pipeline route there are only very few single houses, at a distance longer than 20 m (in compliance with the DM 17/4/2008).

2.2.5 Distances from power lines, parallelism and crossings with other utilities

In addition to the one provincial road and one minor asphalt road crossing by landfall microtunnel upstream of KP 0 there is one more provincial road crossing at KP 6.5 and eight more minor municipality road crossings. Details of all the asphalt road crossings and the proposed construction method are provided in the table below.
2.2.6 Corrosion protection

The onshore part of the pipeline system at the landfall in Italy consists of two parts:

- The station piping of Pipeline Receiving Terminal (PRT).
- The pipeline, with a length of 8.2 km, between Landfall and PRT.

Corrosion protection of the on-shore pipeline and station piping is first of all achieved by high quality coatings. The table below lists the coating types as will be used in the TAP project

<table>
<thead>
<tr>
<th>Application</th>
<th>Factory coating</th>
<th>Field coating</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td><strong>Standard</strong></td>
<td><strong>Type</strong></td>
</tr>
<tr>
<td>Product pipe in trench (open trench)</td>
<td>3LPE</td>
<td>EN ISO 21809-1</td>
</tr>
<tr>
<td>Product pipe inside casing and micro tunnel</td>
<td>3LPP (for ambient temperature &gt; 0 °C)</td>
<td>EN ISO 21809-1</td>
</tr>
<tr>
<td>Casings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product pipe installed by ramming (pipe jacking), auger boring (open front drilling) or horizontal directional drilling (HDD).</td>
<td>3LPE and Gf-UP (glass fibre reinforced, unsaturated)</td>
<td>EN ISO 21809-1 / ISO 21809-3 (TAP specification)</td>
</tr>
</tbody>
</table>

Table 2-9: Crossings of the onshore pipeline

<table>
<thead>
<tr>
<th>No</th>
<th>Type</th>
<th>Name</th>
<th>Chainage [m]</th>
<th>Region / Province</th>
<th>Municipality</th>
<th>Crossing Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Provincial road</td>
<td>SP366</td>
<td>-500**</td>
<td>Puglia/Lecce</td>
<td>Melendugno</td>
<td>Landfall micro-tunnel</td>
</tr>
<tr>
<td>2</td>
<td>Municipal road</td>
<td>name unknown</td>
<td>0</td>
<td>Puglia/Lecce</td>
<td>Melendugno</td>
<td>Landfall micro-tunnel</td>
</tr>
<tr>
<td>3</td>
<td>Municipal road</td>
<td>Strada comunale S. Viceta</td>
<td>601</td>
<td>Puglia/Lecce</td>
<td>Melendugno</td>
<td>Open cut</td>
</tr>
<tr>
<td>4</td>
<td>Municipal road</td>
<td>Strada comunale S. Viceta</td>
<td>1.131</td>
<td>Puglia/Lecce</td>
<td>Melendugno</td>
<td>Open cut</td>
</tr>
<tr>
<td>5</td>
<td>Municipal road</td>
<td>Strada comunale S. Viceta</td>
<td>2.027</td>
<td>Puglia/Lecce</td>
<td>Melendugno</td>
<td>Open cut</td>
</tr>
<tr>
<td>6</td>
<td>Municipal road</td>
<td>Strada comunale S. Viceta</td>
<td>4.012</td>
<td>Puglia/Lecce</td>
<td>Melendugno</td>
<td>Open cut</td>
</tr>
<tr>
<td>7</td>
<td>Municipal road</td>
<td>Strada comunale S. Nicolata</td>
<td>4.620</td>
<td>Puglia/Lecce</td>
<td>Melendugno</td>
<td>Open cut</td>
</tr>
<tr>
<td>8</td>
<td>Municipal road</td>
<td>name unknown</td>
<td>5.611</td>
<td>Puglia/Lecce</td>
<td>Melendugno</td>
<td>Open cut</td>
</tr>
<tr>
<td>9</td>
<td>Municipal road</td>
<td>name unknown</td>
<td>5.906</td>
<td>Puglia/Lecce</td>
<td>Melendugno</td>
<td>Open cut</td>
</tr>
<tr>
<td>10</td>
<td>Provincial road</td>
<td>SP2 Strada prov. Lecce-Melendugno</td>
<td>6.452</td>
<td>Puglia/Lecce</td>
<td>Melendugno</td>
<td>Trenchless</td>
</tr>
<tr>
<td>11</td>
<td>Municipal road</td>
<td>name unknown</td>
<td>7.602</td>
<td>Puglia/Lecce</td>
<td>Melendugno</td>
<td>Open cut</td>
</tr>
</tbody>
</table>
For all components which – due to their geometric form – cannot be coated like a pipeline: for valves, fittings, T pieces, etc

<table>
<thead>
<tr>
<th>Component Type</th>
<th>Coating Material</th>
<th>Coating Standard</th>
<th>Additional Coating</th>
<th>Coating Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>For all components</td>
<td>PUR</td>
<td>EN 10290</td>
<td>PUR</td>
<td>EN 10290</td>
</tr>
<tr>
<td>Air to ground transitions</td>
<td>3LPE</td>
<td>EN ISO 21809-1</td>
<td>PUR or 3LPE + EP-GFRP</td>
<td>EN 10290</td>
</tr>
<tr>
<td>Internal pipe wall</td>
<td>Epoxy resin</td>
<td>EN 10301</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 2-10: Onshore pipeline coating specifications

To prevent corrosion at coating defects of the pipeline, a cathodic protection system will be installed. The cathodic protection system will consist of:

- A DC rectifier, incl. an anode bed, for impressing current to the pipeline
- Test posts for regularly checking of the system performance

Pipelines inside the PRT will be in electrical contact with stations groundings and station foundations. For several reasons, like safety which require grounding of metal objects in hazardous areas, it will not be possible to eliminate these electrical contacts.

In order to achieve protection under these circumstances, a so-called local cathodic protection system will have to be installed. A local cathodic protection system is aiming at achieving sufficient soil-to-pipe potentials by changing (relative to remote earth) the soil side of the potentials.

A local cathodic protection system will consist of:

- Isolating material at surfaces of foundations with reinforced concrete. The isolating material is needed to uphold the relative positive soil potentials in the vicinity of the pipeline.
- A transformer/rectifier to impress current to the anodes distributed throughout the terminal.
- Single anode controls, in combination with distribution boxes, to prevent that the local cathodic protection system will cause corrosion interaction with other objects in the vicinity of the terminal.
2.3 Pipeline Receiving Terminal (PRT)

2.3.1 Technical data

The Pipeline Receiving Terminal is required to control the flow of the gas delivered into the Snam Rete Network. The upstream pipeline is designed for a pressure of 145 bar (g) and the downstream pipeline is designed for a pressure of 75 bar (g).

The main design conditions are the following:

- Design pressure up to pressure reduction: 145 bar (g);
- Design pressure downstream pressure reduction: 75 bar (g);
- Supply pressure at SRG network: 75 bar (g) max;
- Pipeline transportation capacity at first design stage: 10 Bcm/y
- Design flow rate for the first design stage: 1,320,000 Sm³/h;
- Nominal flow rate for the first design stage: 1,190,000 Sm³/h
- Pipeline transportation capacity at final design stage: 20 Bcm/y
- Design flow rate for the final design stage: 2,640,000 Sm³/h;
- Nominal flow rate for the final design stage: 2,380,000 Sm³/h
- Minimum supply temperature at SRG network: 3 °C.

Pipeline Receiving Terminal will include:

- Filter package at inlet;
- Flow and pressure control valves;
- Gas heating equipment;
- Utility, such as instrument air, fuel gas supply, diesel power generation, fire fighting equipment, condensate tank, heating system;
- PIG trap station;
- Fiscal metering (USM) with redundancy;
- 2 vent stacks
- Supervisory control center for the entire Greece-Albania-Italy pipeline.
2.3.2 Location of the Station

The PRT will be installed within the border of the Municipality of Melendugno, approximately 8 km inland from the seashore. The connection to the SNAM Rete Gas (SRG) network will be at the fence of the PRT.

2.3.3 Process description and functions

The maximum gas flow design rate of TAP Terminal is 10 Bcm/year for initial installed equipment. The capacity increasing to 20 Bcm/year will be done by adding additional equipment (pumps, heaters, entire trains etc.). The purpose of the gas metering station is to perform fiscal measurement of the quantity and quality of gas to be delivered from TAP Terminal to SRG Network.

The purpose of the terminal inlet section is to receive the incoming gas feed and to act a point of isolation (and emergency shutdown by means of ESD valves) between the BVS close to the coast and the Terminal. The inlet facilities also contain a Pig Receiver.

For availability reasons the terminal will be provided in a block design for the different process units (filter, two electrical heaters and two gas fired boilers, heat exchangers, pressure/flow control and metering) with 3 identical gas processing units each fed from a single header immediately downstream of the terminal inlet facilities. Between each process unit the gas will be again collected in a common header and then again split up to the next process unit.

The first process unit consist of filter separators which remove potential solids and liquids from the gas stream before the gas enters the conditioning facilities (heater, pressure/flow control unit). Liquids will be collected in this process unit and further fed into the closed drain system which leads to a condensate tank.

The heating of the gas to be received shall be done to guarantee the minimum delivery gas temperature, downstream the pressure reducing system; this operation may be required only in transport transient condition (packing/depacking operation, start-up etc.) and in case of quick fluctuation of the pressure in the downstream SRG network. The gas heating will be done by heat exchangers, based on hot water circulation. Hot water shall be supplied by a closed circuit production system using electrical heaters and gas fired boilers. The heating system is designed...
to provide in total 8.6 MW duty. The electrical heaters which are designed to provide a duty of approximately 2 MW, will cover most of the operational heating requirements. The gas fired boilers, designed for the remaining duty, are intended to cover mainly start-up and abnormal operation conditions. Thus, local air emissions from heating will be sporadic.

In order to protect downstream equipment and systems against over-pressure (145 barg vs. 75 barg) a pressure/flow control unit controls the flow rate to the downstream network and simultaneous reduces the pressure to the downstream network pressure. Additionally a HIPPS (High Integrity Pressure Protection System) shall be installed between pressure/flow control unit and metering unit. This system consists of two serial mounted independent quick self-closing valves (one is purely mechanical, the second one is an instrumented safety system), which are maintained open as long as the downstream pressure is below the set point.

The quantity of the natural gas to Snam Rete network will have to be measured for custody purposes. This will be done by using ultrasonic flow meters (USM). To fulfil the strict requirements of custody transfer measurement two identical USM will be installed in serial, in each meter run to compare the accuracy of the individual meter. The quality of the natural gas to SRG network will be analyzed for custody purpose by a Gas Analysing Unit.

A fuel gas unit will be provided for the conditioning of the fuel gas to the requirements of the heating medium. The fuel gas is taken from the outlet side of the pipeline receiving terminal as the lowest pressure level is expected there. As the fuel gas might be also taken during terminal shut down from Snam Rete Network the fuel gas stream will be measured with a flow meter suitable working a measurement required for invoicing.

The closed drain system will be collected in a suitable condensate tank, 10 cubic metres in volume. The closed drain system will be sized for the final TAP Terminal flow rate (20 Bcm/year), considering the quantity of liquids discharged from Main Gas filters, and the hypothesis that a liquid slug can enter the Terminal. The collected fluid shall be removed by road tanker.

For surface/rain water two separate drainage systems are required for the TAP Terminal:

- Process areas
- Other areas (utilities, buildings etc.)
Their purpose is to collect and discharge the applicable waste water preferably to the public waste water network. Surface water from potential polluted areas will be carried to an oil separator and then into the sewage system. This sewage system will also be used for the discharge of sanitary waste water.

Instrument and plant air systems are designed to supply approx. 200 Sm³/h, at 12.5 to 15 barg pressure of dried air to the instrument and plant air distribution. The air compressors are operated such that the duty compressor auto starts/stop as required.

The depressurization of the station piping/equipment, both in emergency and in maintenance condition, will happen through two dedicated vent stacks, to be installed in a fenced area within TAP Terminal. The cold vent stacks are designed to blow down the terminal piping and equipment. The onshore pipeline section can be depressurised via the PRT (mobile vent connection at the pig receiving area) or by line packing of the neighbouring sections to avoid local emission; the offshore pipeline is foreseen, if necessary, to be de-pressurized at the compressor station in Albania. The vent stacks are designed to blow down the entire volume between the inlet- and outlet ESD valves from design pressure (145 barg) to 6.9 barg within approximately 15 min. Gas dispersion as well as heat radiation levels have been evaluated as per the requirements of EN 23251. According to radiation calculations, the vent stack height will be 10 m, with a sterile area radius of 86 m where a heat load of 5 kW/m² could occur.

The main tank of diesel oil with a capacity of 16 m³ is designed to feed diesel fuel to both the emergency generator daily tank and the firewater emergency pump daily tank. The diesel oil will be supplied to the TAP Terminal by road tankers.

The potable water system is intended to provide potable water to the buildings expected to be in the TAP Terminal (such as Workshop/Storage Building and Administration Building), to satisfy personnel needs. The system will be fed from existing water network via a dedicated supply line or from a new well on the station site or nearby.

The service water system shall supply service water to:

- the various plant areas of the Terminal, for general purposes and to satisfy the equipment washout needs,
- the Fire Extinguishing Water Tank (aboveground).
The fire water system will be sized according to Italian standard UNI EN 10779 for industrial areas (192 m³/hour over a guaranteed period of 2 hours, plus 50 m³ buffer) and has to be evaluated with local fire brigade. The fire water system will have a stored volume of roughly 450 m³. The fire water tank is always on line. Filling of the fire water cistern is a manually controlled operation.

2.3.4 Mechanical equipment

2.3.4.1 Design Parameters (Process Requirements)

The main piping and fittings of the PRT station are categorized into two main sections. In the inlet area, the piping and fittings will be designed for a maximum pressure of 145 barg and a maximum temperature of 65 up to 100°C. On the outlet side of the PRT station the piping and fittings are to be designed for a maximum operating pressure of 75 barg and a maximum temperature of 65°C.

The particular maximum quantity to be transported in the individual piping sections, and a flow speed of approx. 15 m/s was used as the basis for determining the nominal diameters.

The underground pipes are designed with an earth cover of 1m. The aboveground pipes are laid close to the ground level, to facilitate the maintenance of the valves and equipment.

The pipes calculation is carried out according to EN 1594 for primarily static stress. Pipe fittings examined as reducers, tees, flanges and branches are calculated according to the relevant PED instructions.

2.3.4.2 Piping design

The piping will be designed according to the project pipe classes. All necessary supports, pipe guides and fixed points are to be determined on the basis of the requirements of the strength calculations and the calculations of the static equilibrium for the piping.
2.3.4.3 Acceptance and testing

All piping to be installed within the station is to be manufactured, tested, and accepted according to the valid EN 1594 and PED worksheets.

2.3.4.4 Strength and leakage tests

After completion of the piping system, a strength test is to be carried out on the components or individual piping sections.

The strength test is to be performed as hydro-test (water based) according to the EN 1594 worksheet.

After completion of the entire piping system, leak tests are to be carried out with nitrogen.

2.3.4.5 Tests of welds

The welded connections are to be tested according to EN ISO 17635. All welded seams are to be 100% tested according to the TAP / E.ON standard.

All connection seams are to be produced as golden welds. The testing of welded seams is to be performed using ultrasonic and X-ray tests.

2.3.4.6 Coating, Corrosion Protection

Piping and plant components are situated above ground to be protected against external corrosion by coating, reference is made to section 2.2.6.

Coating of piping laid underground and coatings performed on the construction site are to be carried out according to national and international guidelines.

2.3.4.7 Acoustic and thermal Insulation

Equipment and piping will be insulated for the purposes of heat conservation, maintenance process of stabilized temperatures during atmospheric temperature changes, condensation presentation and burn presentation of personnel.

The acoustic insulation includes the entire piping system situated above ground, as well as any fittings or processing equipment.

The implementation of the acoustic insulation is to be carried out on the basis of the noise study.
2.3.4.8 Pipe Stress Analysis

A pipe stress analysis will be accomplished for all new pipe systems. Within the scope of this pipe stress analysis (PSA) there will be calculated the maximum allowable stress as well for every single component and the nozzle loads from equipment. Based on the PSA the foundations as well as support loads are determined. These loads will be transferred to the civil division.

After the PSA the pulsation study will be prepared.

2.3.5 Control system

The TAP control system will permit full operational monitoring and control of the terminal. Moreover, inside the PRT the control and supervision centre of the entire pipeline will be located. Detailed operating procedures for the pipeline control system will be developed. These procedures will be in place ahead of pipeline operation. The operating procedures will typically address the following:

- An administrative system covering legal considerations, work control and safety;
- Clear and effective emergency procedures and operating instructions;
- Adequate and regular training of all personnel involved in operational and maintenance issues;
- A comprehensive system for monitoring, recording and continually evaluating the condition of the pipeline and associated equipment;
- A system to control all development or work in the vicinity of the pipeline;
- Effective corrosion control and monitoring;
- A system to collect and collate information on third party activities; and
- Monitoring of restoration, and the undertaking of remedial work as necessary.

The pipeline including the entire offshore part between Albania and Italy will be monitored and controlled 24 hours a day and 365 days a year from a central control room. The monitoring system is a SCADA System (System Control and Data Acquisition), during operation, leak detection will be by continuous measurements of pressure and flow rates at the inlet and outlet of the stations and pipeline. If a leak is detected, an alarm is triggered. To allow internal inspection, pigging facilities will be installed. The pipeline system has been designed to allow use of instrumented pigs.
2.3.6 SCADA and Communication Systems

2.3.6.1 SCADA

The Supervisory Control and Data Acquisition System is a backend system that has overall control of the pipeline and station operation. It is one of the main instances regarding core business aspects. It comprises a series of control and acquisition functions that include, amongst others, the

- Transport operation (monitoring, process insight, alarms, thresholds, etc.)
- Overall pipeline security including all BVS and tie-in valves of each station
- Overall pipeline Ordered Shutdown triggering
- Logging
- Simulation
- Engineering
- Etc.

The SCADA system will be placed in the Supervisory Control Center and be backed up with a Backup Supervisory Control Center. The BSCC will take over in failed attempts of use the SCC. SCADA heavily relies on the communication infrastructure alongside the pipeline, the so called Passive and Active Optical Network (PON/AON).

2.3.6.2 LDS

The Leak Detection System shall eliminate the threat of undetected and unwanted depressurization of parts or the entire pipeline. It monitors by technical means the status of the pipeline and warns or acts in case of imminent danger to the pipeline itself or the business (loss of gas). A mechanism will be implemented relying on sensors along the pipeline to detect malfunctions. A certain level of automation can be achieved to prevent losses and danger to human life. The LDS will report to the SCADA system.

2.3.6.3 PON

The Passive Optical Network is the physical transport layer of the communication backbone. It serves as the carrier for the numerous systems with communication needs. Infrastructure-wise optical distribution frames will offer the possibility to implement various systems for wide area network connections. It comprises a number of fiber optical cables, installed along the entire
pipeline. Spare capacities for future expansions or third party business (like bright/dark fiber interconnections for telcos or data carriers) can be allocated.

2.3.6.4 AON

The Active Optical Network is the actual communication backbone. It features a setup of different channels, protocols and capacities to allow flexible interconnection of all relevant systems. Distances of up to one hundred (100) kilometers per hop can be spanned. By making the AON available in all stations and block valve stations various services can be delivered to any point in the ring, like telephony, video conferencing, data access, remote control, etc. It is also able to deliver redundancy.

2.3.7 Alerting Systems and Monitoring

2.3.7.1 Gas detection System (GDS)

The Gas Detection System detects gas leakages on the station inside the fuelgas building as well as in the open range, e.g. gas heaters, metering piping and other above ground piping within the station limits. One warning and one alarm can be caused by the GDS, the detection of 20% and 40% lower explosion limit in the proximity of its sensors. The GDS reports to the station's ESD system as well as to the station's DCS and to the SCADA system.

2.3.7.2 FDS

The Fire Detection System detects smoke and fires within the station buildings, inside the fuelgas building and in the open range, e.g. gas heaters, metering piping and other above ground piping within the station limits. One warning and one alarm can be caused by the FDS, a fire warning and a fire alarm. The FDS reports to the station’s ESD system as well as to the station’s DCS and to the SCADA system.

2.3.7.3 AVAS

The Audio Visual Alerting System generates an audible and visible alert notification, distributed across the entire station. It serves as evacuation alert to all personnel in hazardous or potentially hazardous areas. The AVAS is triggered by the FDS, GDS or manually in case of gas, fire or any other situation deemed hazardous. Among others it reports into the SCADA system.
2.3.8 Security Systems

2.3.8.1 CCTV

The Closed Circuit TeleVision System comprises a set of (nightvision) cameras placed within the station’s fence and spans a surveillance perimeter around each station or object. Virtual fencing enables the system to automatically display trespassers or intruders violating a certain area around the station. It can be coupled with the SCADA system to generate alarms while a station is unmanned.

2.3.8.2 ACS

The Access Control System provides security measures and their administration to the station’s personnel. Electronic badges enable employees or guests to open doors, gates, barriers or gain access to the SCADA or station control system. Also evacuation purposes are served by tracking the presence of employees or guests within the station limits. The ACS reports to the SCADA system.

2.3.9 Power supply and electrical components

Power requirements of the pipeline receiving terminal (PRT) will be met by a medium Voltage electricity transmission line and substation which will connect the installations with medium voltage network in the station area. For back-up power supply diesel engine driven power generators are provided.

The following electrical systems will be installed:

- Transformers
- Medium voltage switchgear;
- Low voltage switchgear;
- Emergency power supply with diesel generators;
- Uninterruptible power supply;
- Grounding and lightning protection;
- Building installations;
- Outdoor lighting.
PRT station will contain electrical circuits with the following voltages:

- Medium voltage three phase AC system;
- 400V three phase AC system (main power system);
- 400 V three phase AC emergency power system;
- 230 V single phase AC UPS system;
- 110 V DC UPS system;
- 24 V DC UPS system.

SCC will contain electrical circuits with the following voltages:

- Line in medium voltage network or 400 V grid operator
- 400V three phase AC system with diesel emergency generator (main power system);
- 230 V single phase AC UPS system;
- 24 V DC UPS system.

The electricity furniture will be done via the public grid and supported by emergency power supply and backup provisions.

2.3.10 Civil design and architecture

2.3.10.1 General

The architectural concept was elaborated with the aim to avoid the station being identified as an industrial plant. Contrary to typical industrial design, the design concept will incorporate design elements of higher aesthetic quality, making references to traditional residential typologies.

In the Salento area there are very diffused characteristic settlements named “Masserie”, two-storey rectangular plan buildings surrounded by productive single storey buildings. Other typical rural buildings in the region are the “Pagghiare” and a very well preserved example is within PRT site.

The main station buildings are arranged to immitate a sort of Masseria settlement with an organic layout that limits the number of buildings. A sort of “dialogue” between new main buildings and existing “Pagghiara” could be initiated by their positioning. The same “dialogic” approach will be followed for materials choice, by alternating plaster and stone for buildings facades.
This architectural concept involving the stringent selection of materials and colours as well as the definition of a high standard of workmanship are the basis of the design. The projected and recessed façade elements which are emphasized by the produced shading are also a central part of the architectural concept. The intention is to adapt the station design within its surroundings and provide technically modern, bright workplaces in a comfortable atmosphere. Colours, materials, shape of buildings and facades will be adapted to the existing rural buildings in the area.
2.3.10.2 Layout

Figure 2-6 Layout (source document: IPR01-ENT-000-Q-DQA-0006)
PRT dimension, with reference to fenced area including the surrounding path, is 12 hectares approximately. The plant layout could be slightly updated during the next detailed design phases, but will in any case be inside the construction yard location.

2.3.10.3 Site location and landscaping

The PRT site is a flat and uncultivated field bordered to South-West by a partially asphalted “vicinale” road that links the town of Vernole to Calimera road. To North, to West and to East the site is bordered by olive-tree cultivated fields and to South by an almost flat uncultivated field.

The area is characterized by land division created by a network of dry stone walls. The PRT site in the West, North and East is also bordered by existing dry stone walls in alternating heights. A periphery fence will be erected at a suitable distance from the original dry walls. This area could be used for landscaping with planting and walkways. The surrounding path at the west side of the station shall be used as a secondary station access simultaneously.

Due to the landscaping a Landscape Impact Mitigation Report will be carried out separately.

2.3.10.4 Building and structures

To lower the visual impact the amount and height of buildings and structures will be minimized. Roofs were designed as flat roofs, indigenous to this region.

All buildings will be single-storey buildings. Due to the outsourcing of some storage capacity and maintenance works (e.g. for huge and heavy valves) the Workshop and Storage Building will not be fitted with a crane, thus the height could be reduced to 5.50 m.

2.3.10.5 Height of buildings

Height of building will not exceed:
- Supervisory Control Center/ Electrical Building: 5.5 m
- Fuel Gas Skid/Sunshade for parking area: 6.0 m
- Workshop/Stores/Staff Building: 5.5 m
- Administration/Building: 8.0 m
- Vents/Stacks: 10.0 m
Pipe bridges and cable bridges have been omitted to avoid an industrial image of the plant.

Great care will be taken in the architectural form of the buildings and their facades to ensure the adaption of the design within its surroundings. Landscaping and plantation between and in front of the buildings could supplement this aim.

2.3.10.6 Colours

The colours of the station design will be adapted to the surrounding natural colours of the existing landscape. i.e.:

- Sandstone masonry or sand coloured facades as presented by the surrounding dry walls and also for buildings in the region
- Colour of the piping
- Colour of the sealing of station area outside of buildings and, the colour of the vents are dependent on the results/proposals of the Landscape Impact Mitigation Report

Stacks will be visually integrated in the boiler house volume in order to minimize “industrial” characteristics.
3 ROUTE SELECTION CRITERIA

3.1 Offshore Section

The selected route will be obtained by the best satisfaction of the following requirements:

A. to reduce the length (in order to reduce the line pipe quantity);
B. to minimise interference with seabottom scars and other seabed features, i.e. geological constraints;
C. to have a minimum number of curves;
D. to have a maximum and possibly stable route radius for each curve (the curve stability could be a special item in areas of potential clayey soils);
E. To minimise the pipeline installation and construction constraints, i.e. obstacles, fishing areas, dumping areas, UXO areas, archaeological areas;
F. to optimise the crossings with other pipelines and cables, i.e. to use a crossing direction as close as possible to the normal one with respect to the routes to be crossed, mainly aiming at reducing the crossing lengths (due to real congested area, it is expected a governing requirement);
G. to minimise interferences with navigation channels;
H. to identify the widest installation corridor in the most critical and uneven areas;
I. to minimise the number, the lengths and the heights of the free spans in the most uneven areas. The number of points with local bend concentration shall be minimised and, if not completely avoided, the relevant stress level has to be minimised;
J. to optimise the pipeline freespan scenario within areas of seabed erosion (it is expected a typical item in the areas where sandy/sediment soil is expected);
K. to optimise the lay away from the landfall;
L. to comply with any 3rd Party and Authority requirements;
M. to minimise environmental impacts.

3.2 Onshore Section

The following general design criteria have been observed for the selection of the onshore pipeline route:
A. to check the route as regards the possibility of restoring the crossed areas, returning them to the morphological conditions and land use existing before the works, thereby minimizing the impact on the territory;

B. to transit, as far as possible, in agricultural areas, avoiding crossings in areas affected by urban and/or industrial development plans;

C. to avoid areas susceptible to hydrogeological instability;

D. to avoid the buffer areas of the springs and wells tapped for drinking water;

E. to avoid, wherever possible, marshlands and peat soil;

F. to reduce to a minimum the restrictions brought about by gas pipeline easements on private property by using, wherever possible, the easement corridors already constructed by other pre-existing infrastructure (natural gas pipelines, channels, roads etc.);

G. to guarantee to the personnel assigned to operation and maintenance of the pipeline the possibility to access under safe conditions.

The pipeline route has, therefore, been checked and defined after a detailed examination of the aforementioned aspects and on the basis of the results of on-site inspections and surveys carried out in the area of interest.

In this sense, analyses and studies have been carried out on all the various situations, of both natural and anthropic origins, that could create criticalities both for the construction and for the subsequent management of the work as well as for the environment in which the work is situated, examining, evaluating and comparing the various possible design solutions from the standpoint of public health, environmental protection, assembling techniques, and time frames required for implementation and environmental restoration.

In detail, the route optimisation has been carried out after the completion of the following operations:

- acquisition of the geographical maps in order to classify the lithotypes present along the chosen route and identify any sensitive areas;
- acquisition of thematic maps and data on environmental characteristics (e.g. vegetation, fauna, land use etc.);
- retrieval of documentation regarding restrictions (environmental, archaeological etc.) in order to identify protected areas;
- acquisition of Municipality Plan of the municipality intersected in order to delimit the expansion areas;
• retrieval of information concerning potential future public works (roads, railways, catchment basins etc.);
• information and preliminary checks with Local Authorities (e.g.: Municipality);
• specialist surveys along the route (special crossings, critical areas etc.).

In particular, the exploration of the route provided the opportunity to carry out the required checks on:
• the geometry of the route;
• the geological and geomorphological conditions of the route;
• the definition of any special works (e.g. "trenchless" solutions);
• the presence of water table (as far as possible).

4 PIPELINE ROUTE DESCRIPTION

4.1 Offshore, Nearshore and Landfall Sections

The pipeline enters the Italian jurisdiction territory in the middle of the straits of Otranto, about 45 km from the Italian coast (KPof 60.14) and reach the territorial waters around KPof 80.63 of the offshore pipeline (see Figure 4-1).

The nearshore section starts from approx. KPof 100.40. At about 95m water depth, the almost straight route is slightly deviated southwest by means of an 3000 m radius, in order to approach the Italian coast following a rectilinear alignment perpendicular to the shoreline.

The final section of the route, approximately 3.600 m long, is straight and crosses a quite gentle slope up to reach a narrow calcarenite beach located in an area North of San Foca village (comune of Melendugno), (see Figure 4-2).

The rectilinear section in the proximity of the coast is needed for the installation of the pipeline inside the landfall tunnel by means of a pull-in method.
The soil in the nearshore and landfall area is characterized by the presence of calcarenite also known as “dune rock” or “dune limestone”. It is a rock formed by the percolation of water through a mixture of calcareous shell fragments and quartz sand causing the dissolved lime to cement the mass together.
Given the features of the affected coastal area, the most appropriate solution is by means of a trenchless technique. The narrow beaches and a road running along the coast do not offer sufficient space for an “open trench” method.
The selection of the landfall microtunnel solution aims at minimizing the impacts of the construction works on the shore and in the nearshore areas allowing to avoid environmental sensitive areas (presence on the seabed of sparse vegetation of Posidonia oceanica).

The tunnel entry point, about 617 m far from the shore line, has been located taking into account the environmental constraints of the area, and is very suitable for the location of the working area.

4.2 Onshore Section

As described in section 4.1 the pipeline landfall will be implemented by means of a microtunnel underneath the coastline and the Provincial Road SP366 between San Foca and Torre Specchia Ruggeri. Also a minor asphalt road is crossed by this landfall tunnel. The tie-in with the onshore pipeline at the end of this tunnel marks the KP 0 of the onshore route and will be located approximately 600 m off the coast (direction south-west). A block valve station is planned to be erected just downstream of this tie-in point.

The planned pipeline route passes in the south of a large topographical depression consisting of a wetland named “Palude di Cassano” (Cassano Marsh), which is under environmental protection (Melendugno Municipality Plan).

From the first open-cut crossing with the “Strada Comunale S. Viceta” at KP 0.6 (south-east of the wetland), the pipeline route runs parallel to this paved municipal road for approximately 3.5 km. In order to minimise impact on properties and landscape it changes the side of this road three times more, at KP 1.1, KP 2 and KP 4. The route continues its course mainly through olive plantations seeking the side of the road where possible, crossing another provincial road, the "Strada provinciale Lecce Melendugno" (SP2) at KP 6.5. At a total onshore route length of approx. 8.2 kilometres, the pipeline reaches the PRT area west of the township of Melendugno.

This terminal station will be situated closed to the border between Melendugno and Vernole, approximately 1.5 kilometres south of the provincial road connecting these towns.

The examined section does not present particular problems and the morphology of the territory consists predominantly of rolling plains, slightly undulating locally.
Figure 4-3: Onshore route, Landfall to KP 4.5 (source document: IPL00-ENT-100-F-DFO-0001)

Figure 4-4: Onshore route, KP 3 to PRT (source document: IPL00-ENT-100-F-DFO-0001)
5 CONSTRUCTION METHOD AND INSTALLATION

5.1 Offshore, Nearshore and Landfall Sections

5.1.1 Pipelaying

The offshore pipeline will be installed using a laybarge. Pipe sections are welded together on the barge and the lengthening pipe string is paid out to the seabed as the barge moves along the route. Special measures will need to be employed (i.e. concrete mattressing or rock dumping) at crossings such as cables, within the surveyed corridor. The pipe-lay operation will be performed on a 24-hour basis to ensure minimal navigational impact on other users and to maximise efficient use of suitable weather conditions and vessel and equipment time. In addition to the installation vessel, additional support, supply and guard vessels will be involved with the operation.

Normal pipe laying activity will consist of the following main operations:

- Pipe Damage inspection
- Firing ramp operation
- Welding
- Lay barge movement
- Pipeline installation

Pipe Damage Inspection
Prior to transfer the single pipe joint from the storage area, a visual inspection will be performed to locate any damage to coating and/or dent, and to assure internal cleanliness. The internal part of the lines will be cleaned and any damage to the pipe coating will be repaired.

Firing Ramp Operation
The laying operations on the firing ramp will be carried out in the following operational sequence:

- Prior to the start of pipe laying, the roller heights and stinger configuration will be established in accordance with laying parameters determined as per stress analysis.
- At the station no. 1, the pipe joints alignment will be completed using pneumatic line-up clamp.
• The root pass will be completed at the 1st station, following which the Lay Barge will move to a distance equivalent to one pipe joint length. Subsequent hot and fill passes will be carried at other welding stations.

• On completion of NDT examination, the field joint coating will be performed.

Figure 5-1 Example of Firing Ramp Operation

Welding
Welding at the firing ramp of the Lay Barge will be carried out using mechanized welding system. The system is completely mechanised and needs the operator intervention only to control the welding parameters. Once the parameters are carefully fixed, the quality of the weld is highly consistent.

The welding procedure and welder qualification will be carried out before mobilisation for the offshore installation work. The qualifications will be performed at selected onshore base. Qualified welders, NDT Operators and Supervisors will be mobilised to perform the work.

Lay barge Movement
After the above mentioned activities are completed on all work stations, the Lay Barge will be moved on its anchors for a distance equivalent to one single joint length, so that new joint can be conveyed to the firing ramp. The movement of the Lay Barge will be achieved by reeving back the bow mooring cables and simultaneously paying out the stern mooring cables (see Figure 5-2).

After the Lay barge has moved for a distance of one joint length, the operation will be repeated at each work station. The anchors movement will be periodically performed with assistance at AHT's and with deployed positioning systems.
The Lay Barge position and heading will be continuously monitored by means of the surface positioning systems. After each joint move, a fix will take the giving joint number, the heading and co-ordinates referred to a station on the firing line. The Lay Barge will be kept on its correct headings so that the pipeline is laid within the required tolerance with respect to the centre line of the theoretical route.

Pipeline installation
The pipeline installation will be performed by means of a pull-in from offshore lay-barge anchored at water depth around 40 m. The anchor pattern does not interfere with Posidonia area. A land based winch, having a pulling capacity of 400 tons, approximately, shall be placed in the working area, in the proximity of the tunnel shaft.
Offshore lay-barge starts the pipeline current laying as soon as the pipe pulling head reaches the launch shaft. The onshore pulling facilities will be demobilized after the laying of a sufficiently long pipe string. The current laying has to be done till the target area located in proximity of Albania.
Figure 5-3 – Schematic figure of Pipeline installation in nearshore section.
5.1.2 Pre-dredging works

A trench shall be excavated, with a Back-hoe Dredger (BHD), before the pipeline installation, between KP of 103.490 and KP 103.381, at a distance of 868m and 977m from the shore line, respectively. The water depth ranges between 18 and 27m.

The scopes of the trench are:

- To prepare an almost strait surface for the pull-in and the laying of the pipeline,
- To recover the MTBM in the proximity of the tunnel exit seawards (KP of 103.500).

The BHD is an excavator which is fixed to a pontoon (see Figure 5-4). The excavator is based on a lowered turntable at the front of the pontoon. Dredging is achieved in the same way a land based excavator. The BHD has a stick and boom with a bucket mounted on it.

The main components of the BHD consist of:

- The hull, contains the engines and the accommodation for the crew
- The excavator, used for the dredging operations

![Side view](image)

**Figure 5-4 Example of a BHD**

Different types of buckets can be used for different soils. For harder material the smaller bucket (7m³) will be used which can penetrate in the material with his teeth's.

Dredging with a backhoe dredge is not a continuous process, but consists of a cycle of Operations.
The bucket is dredging into the subsoil by a backward movement of boom and upward movement of stick and bucket. When the bucket is filled, a further upward movement of the boom and stick is ensuring sufficient height above the bottom to start swinging. The material will be discharged sideway of the trench and will be used for the backfilling after the layng of the pipeline.

5.1.3 Post-trenching works

A post-trenching machine may be utilised to lower the pipe into the soil to an assigned embedment, and provide a suitable cover. The trenching systems usually consist in ROV equipment to perform trenching tasks. These machines utilize predominantly jetting based excavation systems, possibly in combination with trenching wheels.

5.1.4 Gravel dumping

The offshore Rock dumping is based on the Fall Pipe Method illustrated in the sketch of Figure 5-5. The method is used for placing gravel heaps in deep water, with a good precision, with the following purposes:

- to provide pre-lay or post lay support to the pipeline
- to cover it for protection purposes or preventing in-service buckling
- to build crossings of existing pipelines and cables.

The vessels which perform gravel dumping are usually multi-purpose, in particular equipped with a flexible fallpipe with an ROV at the lower end for better positioning. Gravel is dumped through the fallpipe at a controlled rate. The vessel moves along the route under dynamic control. The ROV is controlled from the ship, and ensure an accurate positioning.
5.1.5 Marine Spreads

The following main marine vessels and their auxiliary spreads will be employed for the execution of the above mentioned works:

- Backhoe dredger
- Motopontoon
- Pipelay barge
- Anchor Handling Tug
- Pipe carrier Barge
- Supply vessel
- Survey vessel
- Crew boat
- Dive Support Vessel
- Fall pipe vessel
- Supply vessel for post-trenching
5.1.6 Microtunnel

The landfall realization of the gas pipeline on the Italian coast is based on micro-tunnel technology, see Figure 5-8 for a sketch of the near shore and landfall solution.

The tunnel route on horizontal plane has been defined considering as follows:

- Straight path on the horizontal plane, in order to allow an easier pull-in and prevent any jeopardizing contact between pipeline and lateral tunnel walls during pull-in;
- The onshore entry point has been defined in order to cross the Provincial Road SP n. 366, outside the area of hydrogeological constraint (Figure 5-6).
- The location of the coast line crossing has been selected to maintain the largest distances from buildings, particularly from those which can accommodate over 100 people.
- The offshore exit point of the micro-tunnel has been defined in order to avoid environmental sensitive areas. In fact, the offshore exit point of the tunnel was set at least 50m away from the border of this vegetation, on the basis of the results of the sediment dispersion study.

![Figure 5-6: Extract of the Hydrogeological Risk Plan](image-url)
The tunnel route on vertical plane has been defined considering as follows:

- Straight or moderately curved path on the vertical plane. The self-weight of the pipeline allows it to follow small curvatures of the tunnel. In this case, tunnel-pipeline contact forces are only related to pipeline self-weight and friction. In case of excessive curvatures, high local contact forces can be activated, due to pulling loads and pipe stiffness.

- In order to obtain a safe cover height, the depth of the tunnel exit point has been set to 3.5m, with an inclination close to the sea bottom slope and set to minimize gravel dumping in front of the tunnel exit.

- The vertical shape of the tunnel to be also defined on the basis of specific analysis of pull-in procedure and of pipeline configuration.
The resulting length of the tunnel is 1485m. The selected diameter is equal to 2.4m inside, 3.0m outside.

A brief description of activities to be performed for micro tunnel realization is reported in the following:

The Micro-tunnel (MT) is executed with the pipe jacking technique which basically consists of pushing reinforced concrete pipes, which have been previously transported to the site, into the soil. The Tunnel Boring Machine (TBM) is lowered into a previously excavated and stable jacking shaft with the required dimensions. The pipes are pushed by means of a set of hydraulic cylinders and a TBM that at the same time of pushing is excavating the front. The soil is removed from the excavation front and transported to the shaft by means of a dedicated circuit.
The sea bottom area in front of the micro-tunnel exit, where the pipeline has to be laid on and pulled to enter into the tunnel, is prepared with pre-trench and gravel dumping, to avoid any pipeline stuck and to prevent damages to the coating.

After completion of the MT and the recovery of the machine from the seabed, the pipeline is pulled in with the help of a winch and sheave system.

Finally the pre-trench is also backfilled. Figure 5-9 shows an overview of the basic layout and principles of the pipe jacking technique.

The micro-tunnelling activities consist of the following phases:

- Site preparation
- Jacking shaft construction (thrusting wall)
• Pre-dredging and exit point preparation
• Drilling the Micro-tunnel along the designed axis
• Works completion inside the micro-tunnel (recovery of slurry and cables and installation of FOC conduits)
• Recovery of TBM inside the pre-dredged exit
• Winch anchoring installation, wire lay and shore pulling
• Pipeline pulling
• FOC pulling
• Site restoration

5.1.7 Shaft

The jacking shaft, is needed in order to ensure the correct alignment of the Micro-tunnel (Figure 5-9), and is prepared at the starting point of the micro-tunnel. TBM shall be designed and tailored in consideration of the expected soil/rock conditions; a hydraulic jacking system pushes the concrete lining pipe continuously (Figure 5-10), a closed loop slurry system removes the spoil from the rotating drilling shield on the front. Intermediate jacking system are designed and installed, when length of drilled section requires, in order to sectionalize the total pushing force.

A lubrication system using special muds, pumped through hoses on the external lining surface, is foreseen to facilitate the concrete lining insertion and progress in the sub soil. The bottom of the shaft has to be realized approximately at the mean sea level. Resulting shaft depth is about 10m.

Figure 5-10 shows a typical launch shaft.

Figure 5-11 shows joints details used to ensure the tightness of the tunnel.
Figure 5-10: Typical launch shaft.

Figure 5-11: Pipe joint detail.
5.1.8 Exit Point - Pre-dredging and TBM recovery

After completion of micro-tunnel construction, TBM has to be recovered. Before recover, TBM is not stiffly kept in place, has a significant buoyancy and could be moved by sea waves-currents. Therefore, the exit location is designed to provide the TBM rests under about 3m of sand, but recover has to be performed as soon as possible.

The recovery of the drilling head at the exit point requires dredging works. For this purpose, the final jacking pipes (the first of which are following the drilling head at the beginning of the job) is dimensioned to ensure the stability of the part of the tunnel without soil cover in the dredged trench.

Work on the pre-dredged trench will be carried out by a backhoe dredger, Figure 5-12, in order to prepare exit point of the tunnel, the laying of the pipeline, and to recover the TBM in the proximity of the tunnel exit, seawards.

Excavated material is temporary displaced on a side of the pipeline route, to be reused in the following sea bottom works.

Sea bottom is pre-trenched in front of the Micro-tunnel and then embankment realized to gently get a smooth pipeline configuration, see Figure 5-13, and facilitate the pipeline laying and its insertion into the tunnel. These activities are performed just after and with the same vessel used to prepare the tunnel exit point for TBM recovery. The water depth is approximately 20m-25m. Pipeline and FOC at the exit point and for a certain length, after their installation, are covered by the excavated material.

![Figure 5-12: Example of backhoe dredger.](image-url)
A barge with a crane will be positioned where the Tunnel Boring Machine will be lifted. The connection of the TBM with the crane will be made by divers. Once recovered, the TBM will be transported to the support harbour. The following Figure 5-14 shows the sequence of performed works.
Figure 5-14: Sequence of drawings and photos of the works performed for recovery an TBM and transport it to the near harbour.

Following the removal of the tunnelling equipment from the micro-tunnel, messenger wires are pre-laid inside the tunnel and a special bell-mouth entry section is installed at the sea end, to safely guide the pipeline from the dredged trench into the micro-tunnel.
There is a potential risk that, as the pipeline is pulled into the micro-tunnel, the weight and dynamic loads may displace the tunnel sections at the entrance leading to a blockage or damage to the pipeline.

This issue is addressed by welding together the leading sections of tunnel segments (this is a standard practice), and by providing a bell-mouth structure at the micro-tunnel exit, for guiding the pipeline into the tunnel. The use of such guiding system allows a smooth transition for the pipeline pull from the seabed into the tunnel.

The bell-mouth structure will provide the following:

- A slope from the dredged trench into the micro-tunnel invert to avoid the pulling head snagging on the face of the tunnel in both the vertical or horizontal plane.
- Sufficient foundation area to avoid the load from the pulling head and pipeline transferring suddenly to the first segment of the tunnel.

The bell-mouth is a steel structure that is positioned using the same crane barge that will remove the TBM. The end tunnel segment to be designed to accept the bell-mouth.

**Pull-in and installation**

Pipeline pull-in inside the micro-tunnel is usually the most challenging activity in landfall realization. Nevertheless, a wide experience is actually available in the world and no specific critical issue is anticipated.

The pulling force required for Pipeline pull-in is preliminary calculated summing friction forces (due to the submerged weight of the pipeline in contact with the sea bottom-tunnel floor) and the pulling force required to the lay barge to prevent overstressing on the pipeline on the laying span. A scheme of the pipeline insertion inside the tunnel is shown in Figure 5-15.

The submerged weight of the pipe with 34mm wall thickness is about 503 N/m.

Applying a friction factor of 0.7, the resulting winch force is about 320 tons.

As preliminary value, considering a relevant margin for contingency, 380 tons pulling force are considered.
In order to prevent relevant contact between pipeline and tunnel wall, and possible damages to the coatings, plastic collars are placed around the pipeline with a certain spacing, see Figure 5-16. To be noted that a plastic collars should be designed for insertion in the tunnel from the offshore exit point, where the pipeline has to move on the soil for about 100m before entering into the tunnel.

The connection of the wires with the pulling winch will be realized with a sloped shaft connection. Figure 5-17 shows the solution designed for TAP project. Other relevant photos of pulling winch and sloped shaft connection to pulling winch are reported in Figure 5-18, Figure 5-19 and Figure 5-20.

Scheme of the tunnel shaft and sloped ramp with the pulling winch is shown in Figure 5-21.
Figure 5-17: Sloped shaft connection with pulling winch

Figure 5-18: Photo of a pulling winch

Figure 5-19: Photo with a relevant example of a sloped shaft connection to the pulling winch

length and size to be defined
Figure 5-20: Photo with a relevant sloped shaft connection realized at Langeled entry point into the micro-tunnel

Figure 5-21: Scheme of Micro-tunnel shaft and sloped ramp with pulling winch

The rough procedure for pipeline installation inside the micro-tunnel (see Figure 31) is:

- Messenger wires pre-laid inside the tunnel are recover on board of the pipelay vessel.
- Main pull wires are inserted and pulled onshore by the winch.
- Laybarge starts to weld together linepipes, the winch placed onshore pulls them.
- Pipe laying continues until the pipe string is installed in the micro-tunnel and reaches the micro-tunnel head.
- The pipeline vessel continues laying the pipeline offshore.
Figure 5-22: Main points of the procedure for pipeline installation inside the micro-tunnel

Finally, at the end of pipeline installation, micro-tunnel will be left flooded with sea water. After the tunnel exit point closure (without sealing), also the entry point will be closed. Venting pipes will be installed at the entry point, allowing any leaking gas (inside the tunnel) to be discharged in the air. Notably, a gas methane detector sensor will also be installed for leak detection.

Yard and facilities
Facilities and features required during micro-tunnel construction include the following:

- Work sites;
• Construction site (with pipe stockyard);
• Pipeline Protection;
• Leak Reduction Instruments;
• Access Roads.

The major plant items needed are bulldozers, heavy excavators, spoil removal trucks, large heavy-lift cranes, standby generators, micro-tunnel boring machine, excavators, rock breakers, etc.

The main equipment used for construction is described in the following, particularly the yacking pit and the pulling spread arrangement.

A temporary worksite is needed for the construction of the offshore micro-tunnel and occupy an area of about 26,000m² (see Figure 5-24). The launch shaft is to be located here. The temporary worksite will also be used for placing the pre-commissioning spread of the offshore pipeline.

A total of approximately 8000 m³ of soil will be temporary set aside in order to prepare the working area. This material will be redistributed on the area after the works completion.

Figure 5-23: Temporary Worksite for Microtunnel and Pre-commissioning spread
Figure 5-24: Schematic of equipment in the Construction yard and Stocking area.

5.1.9 Jacking pit

Secant piles are a common and fast technique to construct the jacking shaft. Since piles are to be inserted in the solid rock, exaction and concrete floor will be executed in dry conditions. The axis of the micro-tunnel to be positioned in the most favourable position in terms of geological conditions. The pit floor to be sloped with the same angle of the micro-tunnel entry. An anchoring arrangement is constructed behind the winch location.

5.1.10 Pulling spread arrangement

A linear winch and reel to be set up with a holdback anchor system. The pull capacity of the winch to be suitable for total pulling and contingency, and fitted with a 3-inch diameter steel wire rope. The winch fixation to be designed to transfer the maximum pulling loads from the winch to the ground and to be constructed, in any case, such as to withstand the maximum pulling force. For the installation of the pulling equipment, a hydraulic mobile crane is anticipated to be frequently on site.
The Pull-in of the 36” gas pipeline inside the tunnel is performed using a winch, as in the scheme reported in Figure 5-25.

**Slurry treatment**

The excavated soil will be mixed with slurry (water) in the TBM extraction chamber. Large slurry pumps in the tunnel section behind the TBM will transport the soil mud mixture through slurry pipes to the departure site. The mud will be de-sanded in a recycling plant. The cleaned slurry will be reversed to the front.

The efficiency of the soil separation plant will be of major importance. Indeed, once the water in the tunnel circuit will get saturated with fine sand or clay particles, the slurry will not be able to take any soil from the machine front anymore. The front pressure will increase and the jacking performance will drop significantly. High front pressures could produce cracks in the overburden which could lead into bentonite escape.

Once the slurry will have been saturated with silt/clay, it will be replaced by water. The saturated slurry will be removed from the slurry containers and disposed into the storage pool for slurry.

While the tunnelling operations continue with water, the dewatering installation treats the saturated slurry.

In a first phase, some polymers will be added to the slurry in order to make small particles bond together.

The flocculated slurry will then enter into a band filter press.

The polymer injection will be fully controlled. Dosage, polymer adaptation and monitoring will be followed during the complete tunnelling operations.

The band filter press basically consists of an upper and a lower permeable belt. Both belts turn at the same speed. The lower belt will transport the slurry from one side of the machine to the other side. During the transport cycle, the space between the two belts will progressively be reduced to squeeze out the water. The dewatered silt/clay will fall on a conveyer belt and will come out of the machine. The soil separated can then be loaded on trucks.
The estimated water that will be utilized for the offshore microtunnel can be estimated in 10,000 cubic meter.

**Cleaning and Hydro-testing**

The Hydrostatic testing operation will commence upon successful completion and acceptance of flooding, cleaning and gauging operation. Hydrostatic testing will be performed as per DNV OS-F101.

Seawater injected during hydro-test shall also be provided by the water-winning system and therefore shall have been subjected to a filtration process with the specification at 50µ particle size and UV sterilised accordingly.

Pressurisation water shall be supplied via the same water-winning system used for flooding, cleaning and gauging and post hydrotest water shall be discharged using the dumpline facility installed in Albania.

Pressurisation of the pipeline shall be conducted at a rate of 0.5barg/min up to 95% of test pressure. At this stage and in accordance with DNV-OS-101 (2012) final pressurisation to the strength test pressure shall be performed at a lower pressurisation rate.

On reaching test pressure, stabilisation of the test medium shall be required prior to starting the 24hr hold period. It is estimated that stabilisation may take up to two days with particular reference to the rate of heat transfer across the pipe wall and the difference between filling water and deepwater sea temperatures. Therefore the overall pipeline hydrotest duration including depressurisation is calculated to take approximately five days.

The sea water volume that will be discharged during cleaning and hydrottest of the whole pipeline can be estimated in 130,000 cubic meter.

**De-Watering**

The pipeline dewatering pig train will be launched from the Italian landfall site and shall incorporate slugs of fresh water to desalinate the pipeline. The pig train design shall also include dry compressed air slugs to remove residual water. The fresh water slugs will be stored in multiple storage bladders and these will be positioned on a prepared stone free area with a slight elevation.

The fresh water pumping equipment shall be flushed prior to use with the first batch of fresh water being injected behind the first pig in the dewatering pig train.

The sea water volume that will be discharged during de-watering of the whole pipeline can be estimated in 65,000 cubic meter.
Air-Drying

After completion of dewatering operations the receiver shall be removed at the Albania pipeline end in order to optimise the pipeline drying operation. The termination flange shall be fully open. Low pressure dry air will be injected from Italy with the dew-point being monitored at both ends. The pipeline shall be deemed dry if no significant dew point deterioration is incurred.
5.2 Onshore Section

The operating phases involved in the construction of the pipeline are described briefly in the subsections below.

A single storage and work site is foreseen mainly as stock and bending yard for the line pipes. The location is at the end of the route at KP 8.2 in a large arable land patch area where also the receiving terminal will be built up. It will be used as the only stockyard for the onshore pipeline in Italy and will be easily accessible through the existing road network (SP366, SP245 and connected asphalt roads).

No accommodation for workers is considered at the aforementioned site. The whole extent of the land parcels affected presumably amounts to

- 33 hectare as land-easement for pipeline safety zone
  - incl. 21 hectare for temporary construction,
- 12 hectare as land acquisition for the permanent receiving terminal
  - incl. 5 hectare for fabrication and material storage.

The area of 21 hectare assigned for pipeline construction includes only partly (up to the extent of the ROW) the temporary worksite which is foreseen for the construction of the landfall microtunnel which is part of the offshore pipeline.

The construction period for the pipeline is estimated with 6 months and for the terminal 18 months. Site preparation (clearing of topsoil and levelling works) should be done in advance to this period. The completion of the landscaping and road construction is considered to follow afterwards.

5.2.1 Pipeline installation

The trench digging operations and pipeline assembly require the opening of a working strip. The overall width of this working strip will be limited to 26 m which is good engineering practice in cultivated areas, one side approx. 11 m wide for the disposal of trench excavated material while the other one side, a strip approx. 15 m wide to allow the pipeline assembling and for the vehicles/machinery transit required for the pipeline construction.

Before opening the working strip, the top soil layer will be set aside at the edge of the strip, for re-use during the restoration phase.
At stretches which are limited to several hundred metres or connected to access roads, the working strip can be reduced to 22 metres due to technical reasons.
The trench will be cut by excavators and or adequate earth moving machinery suitable for the morphological and lithological characteristics of the ground to be crossed (excavators in loose ground, hydraulic hammers in rock). A pre-defined sand bedding will be applied to the trench bottom, when the required conditions are not reached (rocky area).

The pipes will be bent where required acc. to the trench dimensions and joined together using a motor-driven welding machine by a continuous wire arc welding process. The pipe joining will be made by connecting and welding several pipes so that, a pipe string is formed aside the trench.

After having performed the anti-corrosion coating check by means of holiday detector to ensure that the coating is perfectly intact, the pipe string section will be lifted and laid down into the trench by sidebooms (especially equipped bulldozers).

The laid pipeline will be buried with a pre-defined padding first, composed alike the bedding of selected material, and then will be backfilled with trench excavation material. Generally, it is strived through insitu preparation process that the quality of the bedding material is achieved so
that all of the excavated material is re-used for the backfilling. Finally the top soil will be spread and the whole working strip will be re-instated.

5.2.2 Crossings

The crossings are implemented as small stand alone “worksites” that come into operation as the line progresses. The crossing installation methods are different and can generally be carried out by trenchless (tunneling or boring) or open-cut techniques, with or without casing pipe. The choice of the installation system depends on a number of factors, including: laying depth, presence of water or rock, intensity of traffic, authority requirements, etc. There is three envisaged trenchless crossings, two of which are actually part of the approximately 1.5 km landfall tunnel as described under the offshore section.

5.2.3 Hydro-test

Following the pipeline construction and backfill, a hydro-test shall be performed, by filling and pressurising the line with water at a pressure of presumably 1.3 times the maximum pipeline operating pressure for a period of 48 hours (according to DM 17/04/2008). Hydro-test is usually carried out on separated pipeline sections dependant on the work progress at road crossings or special sections. The approximate volume of water required for the hydro-test of the onshore pipeline is 4,900 cubic metres.
6 CONSTRUCTION TIMING

The following Table 6-1 provides a summary of the expected timescales for the construction of the major project Phases.

<table>
<thead>
<tr>
<th>Construction site and work sites</th>
<th>1 month</th>
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Table 6-1: Duration of Construction of Project Phases

The whole project will be constructed within approximately three years, in respect of the touristic season (from June to September) the activities on the coast will be suspended.
ANNEX A - PHOTOGRAPHIC REPORT

Photo no. 01  
KP 0.0  
View to East  
Maquis crossed by landfall tunnel

Photo no. 02  
KP 0.0  
View to West  
Area of microtunnel entry point inside “leisure area”
Project Title: Trans Adriatic Pipeline – TAP
Document Title: Project Basic Design - Italy

Photo no. 03
KP 0.3
View to North
Pipeline route leaving the “leisure area”

Photo no. 04
KP 0.6
View to West
Asphalt road and dry stone wall crossing near an existing water treatment plant

Photo no. 05
KP 1.1
View to West
Asphalt road crossing in densely vegetated area
Project Title: Trans Adriatic Pipeline – TAP
Document Title: Project Basic Design - Italy

Photo no. 06
KP 2.0
View to West
Asphalt road and dry stone wall crossing

Photo no. 07
KP 3.8
View to East
Young olive plantations

Photo no. 08
KP 3.9
View to South-West
Approaching asphalt road and dry stone wall crossing
Photo no. 09
KP 4.6
View to South
Asphalt road and stone wall crossing

Photo no. 10
KP 4.6
View to West
Typical olive orchard on the route

Photo no. 11
KP 4.9
View to North-East
“Pagghiara” hidden in the olive trees in vicinity to the route
Photo no. 12
KP 5.3
View to West
“Pagghiara” hidden in the olive trees in vicinity to the route

Photo no. 13
KP 5.6
View to North
Asphalt road crossing

Photo no. 14
KP 5.6
View to North-West
“Pagghiara” hidden in the olive trees in vicinity to the route
Project Title: Trans Adriatic Pipeline – TAP
Document Title: Project Basic Design - Italy

Photo no. 15
KP 5.8
View to West
Asphalt road crossing

Photo no. 16
KP 5.9
View to South
Area with olive trees in the vicinity to the route (number and proximity to the pipeline to be verified)

Photo no. 17
KP 6.4
View to East
Provincial road crossing (trenchless)
Project Title: Trans Adriatic Pipeline – TAP
Document Title: Project Basic Design - Italy

- Photo no. 18
  KP 7.5
  View to West
  Asphalt road crossing

- Photo no. 19
  KP 7.6
  View to South
  “Pagghiara” in vicinity to the route

- Photo no. 20
  KP 8.2
  View to North
  Area for Pipeline receiving terminal
ANNEX B – TYPICAL DRAWINGS

B1 – PIPELINE OVERVIEW

General Overview of the Project – Italian Section
IPL00-ENT-100-F-DFO-0001--TAP Route Italy onshore
CPL00-ENT-100-F-DFT-0001—Pipeline Flow Diagram

B2 – PIPELINE TYPICALS

CPL00-ENT-100-F-DFT-0011--Working Strip
IPL00-ENT-100-F-DFT-0001--Typical Tench for 36 inch Pipeline
CPL00-ENT-125-F-DFT-0003--Pipeline Crossing with underground Obstacles
CPL00-ENT-125-F-DFT-0004--Minor Road Crossing (open-cut)
CPL00-ENT-125-F-DFT-0005--Major Road Crossing with casing pipe (thrust boring)
CPL00-ENT-125-F-DFT-0006--Pipeline Crossings with Future Road (open cut)
CPL00-ENT-125-F-DFT-0012--Concrete Slab Protection for dirt roads
CPL00-ENT-109-K-DFT-0008--Pipeline Marker Post
CBV00-ENT-100-F-DFT-0016—Layout of the Block Valve Station

B3 – STATION LAYOUT

IPR01-ENT-000-P-DPP-0001-- Pipeline Receiving Terminal – Flow Diagram
IPR01-ENT-000-Q-DQA-0006--Layout Pipeline Receiving Terminal
Project Title: Trans Adriatic Pipeline – TAP
Document Title: Project Basic Design - Italy
Reduced working strip

- 36" Pipeline Italian section -

X: Depending on equipment

approx. 22 m

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<th>G</th>
<th>H</th>
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GENERAL COMMENTS:

- ALL DIMENSIONS WITHOUT UNITS ARE IN METERS.
- ALL DIMENSIONS ARE TO BE USED AS MINIMUMS AND SHALL BE FIELD VERIFIED BY CONSTRUCTION CONTRACTOR.
- ALL REQUIREMENTS SPECIFIED IN THE CLIENTS CROSSING PERMIT SHALL BE CONSIDERED.

NOTES:

1. FIELD BENDS ARE PREFERRED, UNLESS HOT BENDS ARE DESIGNATED IN THE DETAIL DESIGN.
### GENERAL COMMENTS:

- All dimensions without units are in meters.
- All requirements specified in the client's crossing permit shall be observed.

### NOTES FOR TYPE I & II:

1. All dimensions (mm) are site-specific.
2. After installing the carrier pipe, the last isolator to be fitted.
3. These dimensions are to be used as minimums and shall be field verified by contractor and adjusted to suit specific crossing profile construction requirements.
4. Line current / casing pipe test station defined in CPL08-ENT-105-H-CPT-0011.
5. CP and MP points at suitable location as required.

### Area Code

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**Project Title:** Trans Adriatic Pipeline – TAP  
**Document Title:** Project Basic Design - Italy

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**Detail Z**

1. Distance between isolating spacers Max. 2.0
2. Length of casing pipe, see construction drawing
3. Effective crossing length (measure perpendicular to road)
4. Water outlet will not be handauged

**Type II**

1. Distance between isolating spacers Max. 2.0
2. Length of casing pipe, see construction drawing
3. Effective crossing length (measure perpendicular to road)
4. Water outlet will not be handauged

---

**View A**

1. Cable conduit
2. Fiber optic cable for telecommunication
3. Casing pipe NPS with coating
4. PE-coating
5. Isolator

---

**Trans Adriatic Pipeline**

**Document Title:** Major Road Crossing with casing pipe (Thrust boring)  
**Client Reference:** E610  
**Client Reference:** IAL00-SPF-000-A-TRE-0001  
**Rev.: 00**
## HEAT & MATERIAL BALANCE PIPELINE RECEIVING TERMINAL, LECCE

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